

NTR&D

North Texas Research and Development Corporation

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Denton, Texas 76203-5073

April 26, 1993

(1)

ONR CONTRACT N00014-93-C-0051

PROGRESS REPORT NO. 1 FOR MARCH 16 - APRIL 15, 1993

SHIPMENT NUMBER NRD0001AA

Significant progress has been made in the first month in setting up the equipment in preparation for producing chaotic behavior of a CO₂ laser. The project goal is to synchronize and control chaos in a CO₂ and other lasers, and thereby increase the power in ensembles of coupled laser sources.

On March 8, 1993, North Texas Research and Development Corporation (NTR&D) was advised by phone, through the offices of Ms. Rocelle Dunson and Ms. Kersten Johnston, that the Office of Naval Research would be approving the proposed effort on Experimental Nonlinear Dynamics of Laser Systems, dependent upon satisfactory negotiation of the contract details. This negotiation was consummated by telephone discussion between Dr. Lon Morgan and Ms. Kersten Johnston, with the payment schedule and reporting times being agreed to. The contract was received via Federal Express on March 25th and executed by Dr. Morgan on March 30th. A March 31, 1993, letter of transmittal provided an explanation of the request to acquire equipment, and returned two original executed contracts. The contract was executed by the Contracting Officer on April 7, 1993, and was received by U.S. Mail on April 19, 1993.

Upon verbal agreement to the contract terms, efforts were initiated to prepare for the Contract start date of March 16, 1993. A project kick-off meeting was scheduled for March 23, 1993. The Principal Investigator, Research Scientists and appropriate staff were advised of the meeting. Time sheets, Certifications regarding the Drug-Free Workplace, a chart of accounts, and a preliminary project time-line were prepared.

Prior to the kick-off meeting, the team members, in coordination, determined that two CO₂ lasers could be made available to the project immediately. This was much earlier than anticipated at the time of Proposal preparation. The first objective in the proposal, to initiate the project investigating the single Nd: YAG laser, was predicated upon the CO₂ laser being available at a later date. Since two CO₂ lasers were available, the project team moved forward with plans to initiate the investigation with the CO₂ lasers as indicated in objective 2. A lease agreement was executed for the equipment listed in the proposal.

The project kick-off meeting was held at 9:45 am, March 23, 1993, with Messr's Cloud, Givens, Kowalski, Morgan, Prasad and West in attendance. A discussion was held concerning the requirements of a Drug-Free Workplace and Certifications regarding same were executed by Kowalski, Prasad, and West and signed by Morgan. Bi-weekly time sheets and the chart of accounts were handed out. Dr. West was established as the approval manager for time sheets. The preliminary Time Line was discussed including contract required reporting times. A weekly technical meeting was set for the project each Tuesday at 9:45 am. A technical discussion reviewed the equipment status and need for a detector early in the project.

Data/idea notebooks were issued to each participant. Project Coordination Meeting Number One was held 9:45 am, March 30, 1993. Messer's Cloud, Perez, Kowalski, Morgan, Prasad, Littler and West were in attendance. Drug-Free Workplace Certifications were signed by Perez and Littler following a discussion regarding same. Other administrative documents were also provided Perez and Littler. Pages two and three of the Contract were discussed to establish the Contractual reporting requirements. Equipment status was reviewed and needs

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ONR CONTRACT N00014-93-C-0051
PROGRESS REPORT NO. 1 FOR MARCH 16 - APRIL 15, 1993 - CONT'D
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discussed, including the option of design and build versus purchase. Guidelines were established for requisition approval. The availability of a Scientist with substantial background in lasers (Dr. Emmanuil Rabinovich) was discussed. A decision was made to attempt to engage Dr. Emmanuil Rabinovich if possible. Dr. Morgan made arrangements for North Texas Research and Development Corporation to hire Dr. Rabinovich. He will be assigned to the project. Dr. Rabinovich's resume and List of Recent Publications is attached to this Progress Report for record purposes and to notify the Office of Naval Research of this change in project staff. He will be an exciting addition to the staff that will accelerate progress of the project.

The second Project Coordination meeting on April 6, 1993, was attended by Cloud, Perez, Morgan, Prasad and Rabinovich. The Drug-Free Workplace was discussed with Rabinovich and Certification regarding same was signed by him. The other administrative details were also reviewed with Rabinovich. The revised Time Line was discussed, and request for additional detail issued.

The third Project Coordination meeting on April 13, 1993, was attended by Cloud, Kowalski, Prasad, Rabinovich and West. The Time Line was discussed and additional input received from West. Available sources for a wide bandwidth HgCdTe detector were pursued and an order placed for immediate shipment. Progress towards schemes to control the laser were discussed. An announcement regarding the 2nd Experimental Chaos Conference was received and discussed.

The Contract Administration Officer was contacted and agreement reached that the first progress report should cover the first month, and is due April 30, 1993.

TECHNICAL PROGRESS:

One method of inducing chaotic behavior in a CO₂ laser is to modulate the beam in the cavity with a frequency between 50 and a 100 kHz. The project has designed two schemes to achieve this modulation. These are through (1) the modulation of the high voltage by inductive coupling and (2) the modulation of the beam by a CdTe electro-optic modulator (EOM).

Modulation of the beam using modulation of the high voltage has been achieved in the laboratory this month. This was accomplished by modulating the high voltage on the laser using an inductor connected to the anode of the laser. Modulation of the laser plasma was confirmed by detecting modulation of the plasma with a light by using a photomultiplier tube. Analysis of the chaotic regime awaits arrival and check-out of the HgCdTe detector.

The second approach is being pursued in parallel with the first. In this approach, an EOM is introduced into the cavity. The aperture of the EOM is smaller than the laser beam, so a collimator, or curved mirror, will be used in the cavity with the EOM to reduce the radial size of the beam. These components require additional room in the laser cavity. The cavity has been extended to accommodate the components and work on the alignment of the components, to achieve lasing, is proceeding. Sources of these mirrors are under investigation at this time and they will be ordered soon.

SUMMARY:

- * Modulation of laser output achieved using modulation of the high voltage.
- * Cavity of laser extended to accommodate EOM and beam expander/collimator approach.
- * EOM design improved with curved mirror replacing collimator.
- * Analysis of chaotic regime pending arrival of HgCdTe detector.

END

EMMANUIL RABINOVICH

OBJECTIVE

To find a research and/or teaching position in the following fields:

Experimental Laser Physics

Fiber Optics

Fiber Sensors

EXPERIENCE

Saratov University, Saratov, Russia

1988-92

Department of Physics

Associate Professor

Taught graduate courses in Optical Resonators and Waveguides, Laser Methods and Measurements, Laser Physics.

Also taught undergraduate courses: Introduction to Optics, General Physics and Electromagnetic Theory.

Directed 2 PhD students.

Conducted research in Physics of Gas and Semiconductor Lasers, Fiber Optics, and Fiber Sensors.

Center for Mechanics and Physics, Saratov, Russia

1966-88

Senior Research Fellow

Designed experiments and conducted research in the Physics of Semiconductor and gas lasers, fiber optics and fiber sensors. The studies were carried out in following areas:

Semiconductor Lasers: space-modulation pattern of injection laser emission, optical multistability in semiconductive lasers, ultrashort laser pulse production.

Experienced in semiconductor lasers with double heterostructure (including distributed feedback lasers) (GaAs/GaAlAs, $\lambda = 0.85\mu\text{m}$; InGaAsP/InP, $\lambda = 1.3\mu\text{m}$; $\lambda = 1.58\mu\text{m}$.)

Fiber Optics: Developed methods and devices for dispersion measurement in multi-mode and singlemode fibers.

Fiber Sensors: Designed various sensors based on laser autogenerator with fiber-optical line of delay for measurement of different physical values.

Gas Lasers: Studied nonlinear dynamics and chaos phenomena in gas-discharge active mode-locked lasers. Developed methods and devices for generation of ultrashort laser pulses. Conducted research of space-modulation characteristics for gas lasers with lense-like medium.

Experienced in working with gas lasers of different types, e.g., HeNe ($\lambda = 0.63\mu\text{m}$; $\lambda = 0.64\mu\text{m}$; $\lambda = 1.15\mu\text{m}$; $\lambda = 3.39\mu\text{m}$; $\lambda = 0.612\mu\text{m}$;) CO₂ ($\lambda = 10.6\mu\text{m}$)

EDUCATION

PhD in Physics, Saratov University, Saratov, Russia	1980
MS in Physics, Saratov University, Saratov, Russia	1966

REFERENCES

Professor Mark Stokman, Physics Department, Washington State University, Pullman, WA 99164. Phone: (509) 335-4777.

Professor Boris M. Schein, Department of Mathematics, University of Arkansas, Fayetteville, AR 72701. Phone: (501) 443-0868.

Professor Meyer Pesenson, Mechanical Aerospace and Nuclear Engineering Department, School of Engineering and Applied Science, University of California, Los Angeles, CA 90024. Phone (818) 246-5182.

OTHER PROFESSIONAL ACTIVITIES

Published 54 papers and received 7 patents. List of the recent publications attached. The complete list is available upon request.

Presented talks at professional meetings.

Member of the International Society for Optical Engineering (SPIE).

PERSONAL

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LIST OF RECENT PUBLICATIONS

1. Rabinovich, E. et al. (1988). "QUASI-PERIODIC OSCILATIONS AND CHAOS IN GAS-DISCHARGE ACTIVE MODE-LOCKED LASER." *Journal of the Optical Society of America*. 5, No. 5 1134-1138.
2. Rabinovich, E. et al. (1991) "SPACE-MODULATION PATTERN OF THE STRIPE-GEOMETRY DH INJECTION LASER EMISSION." *OSA Proceedings on Nonlinear Dynamics in Optical Systems*, Neal B. Abraham, Elsa M. Garmire, Paul Mandel. eds. (Optical Society of America. Washington. D.C.) 7, 96-100.
3. Rabinovich, E. et al. (1991) "MULTISTABLE OPERATION EFFECT ON THE LOW FREQUENCY NOISES IN THE DELAYED FEEDBACK INJECTION LASER." *OSA Proceedings on Nonlinear Dynamics in Optical Systems*, Neal B. Abraham, Elsa M. Garmire, Paul Mandel. eds. (Optical Society of America. Washington. D.C.) 7, 436-439.
4. Rabinovich, E. et al. (1991) "BIFURCATION OF THE PERIOD ADDING AND TRANSITION TO CHAOS IN A LASER GENERATOR WITH DELAYED FEEDBACK" *OSA Proceedings on Nonlinear Dynamics in Optical Systems*, Neal B. Abraham, Elsa M. Garmire, Paul Mandel. eds. (Optical Society of America. Washington. D.C.) 7, 415-419.
5. Rabinovich, E. et al. (1991) "MODE-SWITCHING INFLUENCE ON THE SPACE-MODULATION CHARACTERISTICS OF DFB LASER EMISSION " *Journal of Technical Physics*, 17, 3, 26-31 (in Russian, English translation available).